PREPRODUCTION INITIATIVE
LOW TEMPERATURE POWDER COATINGS
COST ANALYSIS

PROTOTYPE SITES: Portsmouth Naval Shipyard
NAS Whidbey Island
NSWC Port Hueneme Detachment Louisville

DESCRIPTION:

The powder coatings currently used by the Navy cure at temperatures above 350^{o}F. This temperature is detrimental to some metallic components, especially those constructed of aluminum. This initiative incorporates the use of powders that cure at lower temperatures (as low as 250^{o}F) to increase the variety of materials that can be powder-coated and further reduce the use of liquid coatings.

DATA COLLECTION PERIOD: September 2002 through January 2005

COST SAVINGS: The alternative examined yields cost savings by reducing the cost incurred by consumables and the labor costs associated with coating the parts.

PREVIOUS METHOD: Liquid Coating

Consumables

Volume of paint thinner[1] (gallons/year):	12
Cost of paint thinner ($/gallon):	$27
Annual cost of paint thinner ($/year):	$324
Number of crossdraft filters (number/year):	1,000
Cost per filter:	$2.08
Annual cost of filters ($/year):	$2,080
Number of gloves[2] (boxes/week):	2
Cost per box:	$8
Annual cost of gloves:	$832
Number of respirators[2] (number/year):	2
Cost per respirator:	$52
Annual cost of respirators:	$104
Number of respirator cartridge sets[2] (number/year):	35
Cost per set of respirator cartridges:	$8
Annual cost of respirator cartridges:	$280

Cost Per Square Foot of Paint

The number 1604 represents the thickness in mils of 1 gallon of water poured into a 1-foot-square box. Typical percentage solids for primer (MIL-P-53022) and topcoats (MIL-PRF-85285) used by the Navy tend to be between 52% and 57% (average of 54.5%).

% solids x 1604 = theoretical coverage @ 100% efficiency ft^2/gal., 1 mil thick

0.545 x 1604 = 874 ft^2/gal.

The measured paint thickness on a typical component is 155 microns, or 6 mils. Transfer efficiency for two air-operated paint pots is typically 40%.

(theoretical coverage ft^2/gal./film thickness mils) x transfer efficiency = actual coverage ft^2/gal

(874/6) x 0.40 = 58.27 ft^2/gal.

Cost per gallon/actual coverage = applied cost per ft^2

($86.83/gallon) x (1/58.27 ft^2/gal.) = $1.49 per ft^2

Annual Cost of Liquid Paint

Average surface area per part x number of parts per year x cost per square foot = average annual cost/year

6.6 ft^2/part x 700 parts/yr. x $1.49/$ft^2$ = $6,884/yr.

Annual Cost of Compressed Air Supply

One scfm of compressed air requires approximately 0.21 kWh to generate. At an electricity cost of $0.08/kWh, the cost of one scfm of compressed air is approximately $0.017/hr.

7 cfm/paint pot x 2 paint pots = 14 cfm

14 cfm x $0.017/hr. x 931 hr./yr. = $222/yr.

Annual Cost of Spray Booth Exhaust

Spray booth opening x design face velocity = exhaust cfm

82 ft^2 x 100 fpm = 8200 cfm

Plant air temperature – average outside air temperature = temperature rise

$70^{o}F – 48^{o}F = 22^{o}F$

Cfm x temperature rise x 1.1 = Btu/hr. @ 100% efficiency

8,200 x 22 x 1.1 = 198,440 Btu/hr.

Btu/hr. x 0.45/100,000 = spray booth exhaust, $/hr.

198,440 x (0.45/100,000) = $0.89/hr.

Hourly cost of exhaust x hours of operation per part x number of parts per year = spray booth exhaust cost/yr.

$0.89/hr. x 1.33 x 700 parts/yr. = $829/yr.

Total cost of consumables per year:	$11,555

Labor

Average number of hours to coat a part:	1.33
Average number of parts per year:	700
Average annual hours coating:	931
Number of people coating:	2
Average personnel pay rate (per hour)[3]:	$30.25
Average annual labor cost for coating:	$56,326
Average number of hours to clean up per shift:	1
Number of shifts per day:	1
Number of working days per year:	234
Number of people cleaning:	2
Average personnel pay rate (per hour)[3]:	$30.25
Average annual labor cost for cleanup:	$14,157
Maintenance labor hours per week:	8
Weeks per year:	52
Number of people performing maintenance:	2
Average personnel pay rate (per hour)[3]:	$30.25
Average annual labor cost for maintenance:	$25,168
Total labor costs per year:	$95,651

Waste Disposal

Filters and PPE disposed of as drummed hazardous waste.

Number of 55-gallon drums/year:	2
Disposal cost per drum:	$21.30
Total drummed disposal cost per year:	$43
Total hazardous waste disposal cost per year[4]:	$43

Total Annual Costs

Item	Cost
Consumables	$11,555
Labor	95,651
Waste Disposal	43
Total	$107,249

PREPRODUCTION METHOD: Low Temperature Powder Coating

Consumables

Cost of Low Temperature Powder

The number 192.3 converts the thickness in mils of 1 gallon of water poured into a 1-foot square box (1604) to a dry equivalent by dividing 1604 by 8.34 lb. per gallon of water. The average specific gravity of low temperature powder coatings is 1.54, per MSDS.

192.3/specific gravity = theoretical coverage, ft^2/lb.

192.3/1.54 = 125 ft^2/lb.

Theoretical coverage/film thickness x % material utilization = actual coverage ft^2/lb.

(125/6) x 0.95 = 19.79 ft^2/lb.

Average cost of low temperature powder coating: $11.82/lb.

Cost per lb./actual coverage = applied cost $/$ft^2$

$11.82 per lb./19.79 ft^2/lb. = $0.60/$ft^2$

Average surface area per part x number of parts per year x cost per square foot = average annual cost of powder

6.6 ft^2/part x 700 parts/yr. x $0.60/$ft^2$ = $2,772/yr

Cost of Spray Booth Exhaust

Spray booth opening x design face velocity = exhaust cfm

82 ft^2 x 100 fpm = 8200 cfm

Plant air temperature – average outside air temperature = temperature rise

70°F – 48°F = 22°F

Cfm x temperature rise x 1.1 = Btu/hr. @ 100% efficiency

8200 x 22 x 1.1 = 198,440 Btu/hr.

Btu/hr. x 0.45/100,000 = spray booth exhaust, $/hr.

198,440 x 0.45/100,000 = $0.89/hr.

Spray booth exhaust cost per hour x hours per part x % of time spraying x number of parts = spray booth exhaust cost per year

$0.89/hr. x 1.18 hr./part[5] x 0.366 x 700 parts/yr. = $269/yr.

Electrical Consumption for Operation

Total electrical specifications for the motors: 460 V, 3 phase, 60 cycles, 23 hp. This gives a full load amperage (for 25 hp) of 31.3A.

Volts x amps x 1.73 x power factor = Watts and Watts/1000 = kW (power factor varies between 0.7 and 0.9. Use 0.75 as a typical figure.)

460 x 31.3 x 1.73 x 0.75 = 18,681/1,000 = 18.7 kW

kW x $0.08/kWh = hourly operating cost

18.7 kW x $0.08 = $1.50/hr.

Proportion of time oven is on:	63.4%
Hours of oven operation per part[5]:	0.748
Hours of oven operation per year:	524
Annual cost of oven operation:	$786

Compressed Air Consumption

One SCFM of compressed air requires approximately 0.21 kwh to generate.

At an electricity cost of $0.08/kwh, the cost of one SCFM of compressed air is approximately $0.017 / hr.

A typical maximum air volume for a powder gun is 6 scfm.
Typical air volume for the collector back-pulse will be around 24 scfm.
Fluidization of the collector will typically require around 8 scfm.
Transfer pumps from the collector to the feed hopper will use about 16 scfm.
Feed hopper fluidization will use about 12 scfm.
A sieve air bearing will use about 4 scfm.
Air blowoff nozzles will use about 40 scfm.

Actual consumption will be less, and not all items are necessarily running all the time. Typical consumption of a powder line with one manual gun would be around 20 to 25 scfm. At $0.017/hr., 25 scfm costs $0.43/hr.

Hours of operation per part:	1.18
Percentage of operation time spent coating:	36.6
Hours of operation per part[5]:	0.432
Number of parts per year:	700
Hours of operation per year:	302.4
Annual cost of compressed air @$0.43/hr.:	$130

Total cost of consumables per year: $3,957

Labor

Average number of hours to coat a part[5]:	1.18
Average number of parts per year:	700
Proportion of total time spent coating:	0.366
Average annual hours coating:	302
Number of people coating:	2
Average personnel pay rate (per hour)[3]:	$30.25
Average annual labor cost for coating:	$18,271

Average number of hours to clean up per shift:	1
Number of shifts per day:	1
Number of working days per year:	234
Number of people cleaning:	2
Average personnel pay rate (per hour)[3]:	$30.25
Average annual labor cost for cleanup:	$14,157

Maintenance labor hours per week:	8
Weeks per year:	52
Number of people performing maintenance:	2
Average personnel pay rate (per hour)[3]:	$30.25
Average annual labor cost for maintenance:	$25,168

Total labor costs per year: $57,596

Waste Disposal

Number of 55-gallon drums/year:	2
Disposal cost per drum:	$21.30
Total drummed disposal cost per year:	$43
Total hazardous waste disposal cost per year:	$43

Total Annual Costs

Item	Cost
Consumables:	$ 3,957
Labor:	57,596
Waste Disposal:	43
Total	$61,596

COST ANALYSIS SUMMARY

Annual Operating Cost

Liquid coating	$107,249
Low temperature powder coating	$61,596
Operating cost change per year	$45,653

INITIAL PROCUREMENT COSTS AND RETURN ON INVESTMENT[6]

Initial Procurement Cost (Low)

Two powder spray outfits	$6,800
Powder spray booth	$56,000
Gas curing oven	$84,000
Permitting	$0
Fire suppression system	$7,000
Total initial procurement cost (low)	153,800

Expected Service Life: 10 years

Return on Investment (per 10-year period): $302,730

($107,249 x 10) – ($153,800 + ($61,596 x 10))

Break-even Point: 3.37 years

Initial Procurement Cost (High)

Two powder spray outfits	$11,050
Powder spray booth	$56,000
Gas curing oven	$202,000
Permitting	$5,000
Fire suppression system	$7,000
Total initial procurement cost (high)	$281,050

Expected Service Life: 10 years

Return on Investment (per 10-year period): $175,480

($107,249 x 10) – ($281,050 + ($61,596 x 10))

Break-even Point: 6.16 years

Notes

1. Changing from a liquid coating system to a powder coating system typically results in the elimination of reportable VOCs present in the solvents and liquid paints. This analysis does not account for any cost savings resulting from the removal of this regulatory reporting burden (e.g., tracking paint volumes purchased, calculating the volume of reportable VOCs used, filing annual reports, etc.).

2. Eliminating the requirements for personal protective equipment (such as gloves and respirators) when using powder coating could allow reduction or elimination of the costs associated with worker exposure (e.g., minimization practices, engineering controls, monitoring programs, and exposure effects) in addition to the savings achieved by the elimination of the consumable purchases themselves. These additional cost savings were not quantified for this analysis.

3. This is an average, unburdened enlisted hourly rate for Fiscal Year 2005.

4. This analysis does not account for the cost of disposal of used solvents (paint thinner) and other associated hazardous wastes. This cost could not be quantified for this analysis.

5: Based on the data collected during the evaluation project, the entire coating application process required an average of approximately 1.18 hours/part. However, for this evaluation, parts were coated on a one-by-one basis. It is expected that a full-scale production low temperature powder coating line would result in throughput times comparable to or less than regular powder coatings (0.21 hours per part).

6: It was assumed that the initial procurement would need to include all major system components. Two scenarios for the initial procurement of the system were evaluated: one low and one high. The low-price initial procurement scenario reflects the lowest price typically paid by the Navy for a powder outfit. This arrangement uses a natural gas-fueled oven and assumes that no costs were incurred to obtain the necessary operating permits. The high-price initial procurement scenario uses an electric infrared oven and assumes $5,000 in permitting costs. The permitting costs for these systems are highly variable, depending on existing site conditions and requirements. It should be noted that the gas oven requires time to heat up and cool down the oven chamber. Because the infrared oven operates on line of sight, it does not have this additional time requirement. In theory, this difference translates into reduced process time and thus reduced operating costs; however, the difference has not been empirically verified and was not accounted for in the cost analysis.